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SYMPOSIUM: ADVANCED TECHNIQUES FOR REHABILITATION AFTER TOTAL HIP AND KNEE ARTHROPLASTY

Multimodal Pain Management after Total Hip and Knee Arthroplasty at the Ranawat Orthopaedic Center

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Abstract Improvements in pain management techniques in the last decade have had a major impact on the practice of total hip and knee arthroplasty (THA and TKA). Although there are a number of treatment options for postoperative pain, a gold standard has not been established. However, there appears to be a shift towards multimodal approaches using regional anesthesia to minimize narcotic consumption and to avoid narcotic-related side effects. Over the last 10 years, we have used intravenous patient-controlled analgesia (PCA), femoral nerve block (FNB), and continuous epidural infusions for 24 and 48 hours with and without FNB. Unfortunately, all of these techniques had shortcomings, not the least of which was suboptimal pain control and unwanted side effects. Our practice has currently evolved to using a multimodal protocol that emphasizes local periarticular injections while minimizing the use of parenteral narcotics. Multimodal protocols after THA and TKA have been a substantial advance; they provide better pain control and patient satisfaction, lower overall narcotic consumption, reduce hospital stay, and improve function while minimizing complications. Although no pain protocol is ideal, it is clear that patients should have optimum pain control after TKA and THA for enhanced satisfaction and function.
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Each author certifies that his institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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Introduction

The Bone and Joint Decade (2001–2010) has been characterized by exciting innovations in total hip and knee arthroplasty (THA and TKA), including minimally invasive techniques, computer-assisted procedures, advanced rehabilitation protocols, and improved perioperative pain management. It is our opinion and the opinion of others that recent improvements in pain management have been the most substantial advances in the practice of total joint surgery [11, 13, 18, 19, 22–24, 26, 34]. It is well-established that more than half of all patients undergoing THA or TKA may receive suboptimal pain control and may experience severe pain in the early postoperative period [6, 8, 9, 15, 29].

The International Association for the Study of Pain (IASP) defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" [14]. Detailed descriptions of the pathways involved in pain generation, perception, and physiologic responses have been published by the American Academy of Orthopaedic Surgeons [5, 25, 29]; nevertheless, pain is still a poorly understood, complex phenomenon. Adequate pain management has become a priority in the minds of the public

and the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) [15, 32]. Pain, which has become the "fifth vital sign" in the view of the JCAHO, demands consideration in the care of the patient, including taking account of pain in the discharge decision as well as in the entire inpatient and outpatient course [25].

The importance of pain, however, extends far beyond the humanitarian and ethical aspects of inadequate pain control. The consequences of severe postoperative pain are prolonged hospital stays, increased hospital readmissions, and increased opioid use with a subsequent increase in postoperative nausea and vomiting, resulting in overall low patient satisfaction and potentially greater cost [13]. Additionally, arthrofibrosis and diminished range of motion are closely related to the degree of postoperative pain [27, 30]. Pain demands treatment, and failure to provide adequate treatment can result in medicolegal action [32].

Although several treatment options involving various combinations of systemic analgesics and/or regional analgesia with or without opioids are available for postoperative pain, a gold standard has not been established. However, there does appear to be a shift towards multimodal approaches which provide adequate analgesia while minimizing opioid-related side effects [11, 19, 22–24, 32, 34].

We will outline the experience at The Ranawat Orthopaedic Center with postoperative pain management over the last 10 years, emphasizing how and why our pain protocol has evolved to the current multimodal approach.

Our Experience with Multimodal Pain Protocols

Our pain management protocol after THA and TKA has undergone multiple modifications over the last 10 years [26, 27]. Regional anesthesia has now taken precedence over general anesthesia. Initially, we used epidural catheter infusions with and without patient-controlled epidural analgesia (PCEA) for 24 hours, but found many patients suffered rebound pain; we subsequently extended its use for 48 hours. We then employed combinations of epidural infusion and femoral nerve blocks, and femoral nerve blocks in conjunction with or without intravenous patient-controlled analgesia (IV PCA). Unfortunately, all of these techniques had shortcomings, not the least of which was suboptimal pain control and unwanted side effects [1–4, 12, 21, 30, 31, 37]. The major side effects that we have often observed included respiratory depression, nausea, vomiting, ileus, urinary retention, pruritis, hypotension, bradycardia, and cognitive changes.

Multimodal analgesia is a multidisciplinary approach to pain management with a goal to maximize the analgesic effect and minimize the side effects of the medications [11, 16, 19, 22–24, 32, 34]. It takes advantage of the additive or synergistic effects of various analgesics, permitting the use of smaller doses with a concomitant reduction in side effects. Because many of the negative effects of analgesic therapy are related to parenteral opioids [37], limiting its use is a major principle of multimodal analgesia.

Over the past decade, a greater understanding of pain mechanisms has led to the concept of preemptive analgesia [11]. Preemptive analgesia involves the administration of analgesics prior to painful stimuli to prevent the establishment of central sensitization and thus the amplification of postoperative pain. It starts before surgery and covers both the period of surgery and the initial postoperative period.

Another new concept is the evolution of the pain service [29]. Acute pain management services include caregivers trained to formulate and provide safe and effective therapy. We believe standardized therapy should be introduced and maintained using specific protocols, with nursing education and consideration of pharmacy interactions. The pain service generally is multidisciplinary and multidepartmental and consists not only of surgeons and anesthesiologists, but also nurses, pharmacists, and physician and nursing assistants.

Thus, the primary goal of modern pain management is to reduce pain at both the central and the peripheral levels, in combination with preemptive analgesia using a multimodal protocol. This strategy should enhance restoration of function by allowing patients to participate in the rehabilitation programs more easily, thereby improving the overall postoperative outcome.

Currently, our practice has evolved to using a multimodal protocol which emphasizes local, periarticular injections, while minimizing the use of parenteral narcotics (Table 1) [22, 23].

Table 1. Ranawat Orthopaedic Center (ROC) cocktail

Medication	Strength/dose	Amount
First injection		
Bupivacaine	0.5% (200–400 mg)	24 cc
Morphine sulphate	8 mg	0.8 cc
Epinephrine (1:1000)	300 μg	0.3 cc
Methylprednisolone acetate	40 mg	1 cc
Cefuroxime	750 mg	10 cc (reconstituted in normal saline)
Sodium chloride	0.9%	22 cc
Second injection		
Bupivacaine	0.5%	20 cc
Sodium chloride	0.9%	20 cc

Clonidine transdermal patch applied in operating room (100 μg/24 hours). No steroid in diabetics, immunocompromised, elderly (> 80 years) or revisions. Vancomycin used if patient allergic to penicillin/cephalosporins.

Importance of Patient Education

Patients who undergo joint replacement often have unrealistic preoperative expectations of recovery, including those for pain and function, which may lead to high levels of dissatisfaction [10, 20]. The preoperative class is one of the best techniques available to educate patients and their families because it provides information on what will happen to them throughout the whole process and substantially eases the fears that the patient may be experiencing [19]. We have found it beneficial for patients and their families to learn in a classroom setting with other patients undergoing the same type of procedure. We believe preoperative booklets and videos improve the patients' expectations, especially if verbally reinforced. The patients have a better idea of what to expect, as they meet the team members and have interactive discussions with them. Patients may thus experience less pain because they are better prepared to cope with pain. It is essential to decrease a patient's anxiety, as this may increase his or her sensitivity to pain.

General versus Regional Anesthesia

Hypotensive regional anesthesia has been associated with fewer complications, as compared with general anesthesia. Apart from lowering the blood loss and preventing deep vein thrombosis, regional anesthesia avoids central nervous depression, has a different spectrum of effects on the cardiopulmonary system, may modify the stress response to surgery, provides excellent pain relief, and allows early painless range of motion and weight bearing, enhancing overall patient satisfaction [13, 17, 28, 36]. For the vast majority of our patients, hypotensive regional anesthesia is utilized; we reserve general anesthesia for rare instances in which the anesthesiologist is unable to perform the spinal or epidural anesthesia for medical or technical reasons (eg, severe lumbar degenerative disease).

Neuraxial Analgesia

A variety of single-dose and continuous-infusion neuraxial (epidural or spinal) techniques may be applied to provide pain control after THA and TKA and we have tried them all.

Single Dose Spinal and Epidural Opioids

Neuraxial opioids provide superior analgesia compared with systemic opioids, but may also be associated with potentiation of the previously mentioned adverse effects [37], as has been our experience. The onset and duration is determined by lipophilicity of the drug [11]. Lipophilic opioids such as fentanyl provide a rapid onset of analgesia, limited spread within the cerebrospinal fluid (and less respiratory depression), and rapid clearance and resolution. Conversely, hydrophilic opioids such as morphine and hydromorphone have a longer duration of action but are associated with greater frequency of side effects as well as delayed respiratory depression. A sustained-release formulation of epidural morphine has recently become available; however, we do not recommend this, as it has been associated with respiratory depression [35].

Epidural Analgesia

Epidural analgesia may consist of a local anesthetic, an opioid, or a combination of both. A pure opioid epidural infusion may not provide adequate analgesia, and a pure local anesthetic may provide dense sensory and motor blockade, such that the patient may not be able to walk or void in the early postoperative period [4]. Thus, a combination of an opioid and a local anesthetic creates a synergistic analgesic effect that allows lower concentration of each component in the solution [4, 11].

Continuous low-dose infusion has been advocated as a method to control postoperative pain [13]. Continuous infusion permits analgesia to be more precisely titrated to the level of pain stimulus and rapidly terminated if problems occur. The technique avoids peak concentrations that follow intermittent boluses and reduces the risk of rostral cerebral spinal fluid spread and delayed respiratory depression. Epidural infusions provide superior analgesia but are also associated with technical failures, hypotension, ileus, urinary retention, motor block that limits ambulation, unrecognized compartment syndromes, and spinal hematoma secondary to anticoagulation [7, 11, 13, 32]. Based on these drawbacks, we do not routinely employ epidural infusions in the postoperative period.

A Cochrane database review concluded that epidural analgesia may be useful after TKA and THA for pain control, but the benefit must be weighed against the frequency of adverse effects [4]. In our unpublished prospective study (presented at the 29th Annual Meeting of the American Society of Regional Anesthesia and Pain Medicine, March 11–14, 2004, Walt Disney World Swan Resort, Orlando, FL), 87 patients with TKA were randomized to receive either a femoral nerve block in the operating room and a bolus on first postoperative day (Group 1), a combination of continuous epidural infusion for 24 hours followed by a bolus of femoral nerve block (Group 2), a continuous epidural infusion for 24 hours

(Group 3) or a continuous epidural infusion for 48 hours (Group 4). Groups 1, 2, and 3 received IV PCA as well. The epidural failed in 20% of cases. Although there was no difference in pain score based on visual analogue scale (VAS) between groups 1, 2, and 4, groups 1 and 4 had the most satisfactory pain control. The worst pain control was after removal of the epidural catheter at 24 hours (Group 3) secondary to rebound pain. Less frequent urinary retention occurred in Group 1. The incidence of nausea and vomiting was similar between the groups. However, the consumption of morphine equivalents was different in all groups, and was highest in Group 1 and lowest in Group 4.

PCEA offers higher analgesic efficacy and lower dose requirements than IV PCA and provides greater control and patient satisfaction than do either single-dose or continuous infusions. However, despite better pain control, patients still prefer IV PCA because of fewer technical problems and side effects, and more uniform and sustained analgesia with more autonomy [29]. We no longer utilize PCA or PCEA, as we have found both modalities associated with high rates of the opioid side effects mentioned earlier.

As a result of these findings, we began experimenting with local periarticular injections in 2004.

Intraoperative Periarticular Injection

We inject a steroid-containing local anesthetic (Table 1) periarticularly in all the soft tissues surrounding the hip and knee. The steroid prevents local inflammation, and morphine stimulates all three opiate receptors (μ, ð, and k) in the joint with less adverse systemic effects [18, 19, 22, 23, 33, 34]. Epinephrine prolongs the action of local agents by decreasing absorption by vasoconstriction via its α-adrenergic effect. We consider these injections the most important and effective component of this pain protocol [22, 23]. Clonidine exerts its effect via its α-2 adrenergic actions and results in potentiation of the synergistic action of local anesthetic and local steroids [16]. Transdermal application of clonidine allows sustained action for several days while minimizing potential adverse effects, including bradycardia and hypotension [16].

Between October 2005 and October 2006, we enrolled 36 patients undergoing THA along with 35 controls and 31 patients undergoing TKA and 29 controls were enrolled in a prospective randomized study with or without a periarticular injection [22, 23]. Patients in the hip study group had lower pain scores and better satisfaction scores (both with $p < 0.05$) on each day of hospitalization. Further, the overall narcotic consumption was lower in this group. More patients in the study group (52%) were able to do active straight leg raise (ASLR) on postoperative day 1. Similarly, the mean duration of hospital stay was less in the study compared to the control group (3.2 versus 4.2 days, respectively). The knee control group consumed the highest amount of narcotics in this study. Functionally, the study group was better able to perform ASLR on Day 1 than the control group (63% versus 21%, respectively).

Postoperative Analgesia

The goals of the postoperative protocol include administration of a variety of agents with different mechanisms of action which exert local and systemic effects, use of agents with combined antiinflammatory and analgesic properties, early conversion of parenteral to oral agents with prolonged effect, use of baseline analgesia to provide more uniform pain control, and minimization of parenteral narcotics and associated adverse effects. We administer three doses of toradol (30 mg IV if less than 65 years old, 15 mg IV if over 65 years old), unless the patient has renal insufficiency. This is augmented with intermittent doses of morphine sulfate at 15 minute intervals (2 or 4 mg), but only if the toradol was deemed ineffective. Oxycontin (oxycodone HCl, Purdue Pharma L.P., Stamford, CT) (10 mg or 20 mg) is begun as soon as the patient can tolerate oral medication, and oxycodone is administered on a PRN basis. Acetaminophen 1000 mg orally is administered as standing doses every 6 hours. Celebrex (celecoxib, Pfizer Inc., New York, NY) (200 mg once daily) is started 8 hours after the last toradol dose and continued for 10 days total. Pantoperazole 40 mg orally is given daily for gastrointestinal prophylaxis.

Deep Vein Thrombosis Prophylaxis

All patients receive 1000 IU of heparin during femoral preparation. The subsequent protocol depends on whether we consider the patients at high or low risk. Patients we consider high risk include those with a history of prior thromboembolic events, substantial obesity, and those who we judge less mobile. For patients that we deem at high risk for thromboembolic complications, we administer warfarin with a target INR of 1.5 to 2 (in order to minimize bleeding complications, especially at the wound site). Patients who we consider at low risk are given enteric-coated aspirin 325 mg twice a day for 6 weeks. All patients also get bilateral pneumatic compression devices in the immediate postoperative period. A Doppler study is performed for patients with calf pain, tenderness, or swelling. Patients with a positive scan are continued on warfarin for 6 weeks.

Postoperative Rehabilitation

Patients are mobilized out of bed on the first postoperative day. A continuous passive machine (CPM) is started on all uncomplicated TKA cases on the first postoperative day. Patients are discharged after they attain the goals of walking independently with support for at least 50 feet, transferring independently in and out of bed and toilet, and having at least 70° to 80° of flexion for TKAs. Most patients attain such flexion by the third postoperative day. All patients have access to physiotherapy after discharge: for patients discharged home we arrange sessions with a physical therapist near their home prior to discharge and for patients discharged to a rehabilitation facility physiotherapy is performed there. The patients are instructed to walk every day, gradually increasing their distance with an eventual goal of 1 mile by 2 months. We encourage discharge to home rather than a rehabilitation facility. Patients are made weight bearing as tolerated and use crutches or a walker until they are able to easily ambulate with a cane. At 6 weeks postoperatively, patients are allowed to walk without a cane in the house and for short walks; a cane is encouraged for longer walks.

Discussion

Over the years, our aim has been to determine the optimal regimen to control postoperative pain while limiting the side effects of medications. We have described how our pain protocol has evolved, and we have detailed how pain is managed today at the Ranawat Orthopaedic Center.

Achieving a nearly painless TKA and THA is within reach using regional anesthesia and multimodal pain management techniques. Patients have greater satisfaction with their operation when they avoid the complications caused by parenteral narcotics. Further, with the multimodal approach, the safety of the operation is enhanced by reducing complications such as respiratory depression, nausea, vomiting, ileus, urinary retention, pruritis, hypotension, bradycardia, and cognitive changes. It is for these reasons that a multimodal pain program with periarticular injection has been a substantial advance in perioperative pain care after TKA and THA.

Unfortunately, we have still not achieved the ideal technique; we have not eliminated the use of opioids, nor have we eliminated pain during the postoperative period entirely. Further research must be conducted to determine how best to eliminate pain without the use of medications that cause unwanted side effects. In addition, additional prospective randomized trials that evaluate innovative protocols such as ours against well-studied regimens (eg, PCA, PCEA) are needed. We believe some of the most exciting developments will be in the realm of pain control.

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